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RESEARCH MEMORANDUM

LOW-SPEED LATERAL-CONTROL INVESTIGATION OF A FLAP-TYPE SPOILER AILERON WITH AND WITHOUT A DEFLECTOR AND SLOT ON A 6-PERCENT-THICK, TAPERED, 45° SWEPTBACK WING OF ASPECT RATIO 4

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

An investigation has been made in the Langley 300 MPH 7- by 10-foot tunnel to determine the lateral control characteristics of a deflector and slot arrangement in conjunction with a flap-type spoiler aileron. The wing had a sweepback of 45° at the quarter-chord line, an aspect ratio of 4, a taper ratio of 0.6, and an NACA 65A006 airfoil section parallel to the free air stream.

The flap-type spoiler, deflector, slot combination was more effective than the unslotted flap-type spoiler aileron alone in producing rolling moment and maintained rolling-moment effectiveness through a range of angle of attack from about -12° to 60°.

INTRODUCTION

Previous research made on spoiler-type lateral-control devices has proved them to be desirable in regard to lateral control, hinge moment, and wing flexibility. The type and location of spoilers on both straigh and swept wings have been considered in references 1 to 13.

The present use of thin, highly sweptback wings makes the flap-type spoiler aileron desirable from a physical standpoint. The flap-type spoiler aileron may be designed, in spite of the thinness of the wings, for any reasonable spoiler projection and would leave the trailing edge of the wing available for high-lift devices.

A significant loss in rolling-moment effectiveness occurred at the higher angles of attack (refs. 1 and 7) when no slot was present behind the various spoiler-type lateral-control devices when used on thin wings. The addition of a slot (refs. 7 and 13) increased the rolling-moment effectiveness of the spoiler-type lateral-control device. Although the use of a slot behind a spoiler-type lateral-control device was known to be beneficial, most of the results have been obtained without a slot inasmuch as the purpose of these investigations (refs. 1, 2, and 8 to 13) was to find the most effective spanwise and chordwise locations and to determine the projection limitations.

In order to determine the effect of a slot on the effectiveness of a spoiler aileron at large angles of attack, a combination incorporating a large slot and a deflector (similar to that used on the unswept wing of ref. 6) was investigated on a 6-percent-thick wing swept back 45° with an aspect ratio of 4 and a taper ratio of 0.6. The investigation, made in the Langley 300 MPH 7- by 10-foot tunnel, does not necessarily represent the optimum combination for this wing but does show the effects of incorporating a large slot and deflector behind the spoiler.

COEFFICIENTS AND SYMBOLS

The forces and moments on the wing are presented about the wind axes which, for the conditions of these tests (zero yaw), correspond to the stability axes. The axes intersect at the intersection of the chord plane and the 25-percent-mean-aerodynamic-chord station at the root of the model.

C_L lift coefficient, $\dfrac{\text{Twice lift of semispan model}}{qS}$

C_D drag coefficient, $\dfrac{\text{Twice drag of semispan model}}{qS}$

C_m pitching-moment coefficient, $\dfrac{\text{Twice pitching moment of semispan model}}{qS\bar{c}}$

C_l rolling-moment coefficient, L/qSb

C_n yawing-moment coefficient, N/qSb

c local wing chord, ft

$\bar{c}$ wing mean aerodynamic chord, $\frac{2}{S}\int_0^{b/2} c^2 dy$, 1.444 ft

y lateral distance from plane of symmetry, ft

b twice span of semispan model, 5.657 ft

S twice area of semispan model, 8.0 sq ft

L rolling moment resulting from spoiler aileron projection, ft-lb

N yawing moment resulting from spoiler aileron projection, ft-lb

q free-stream dynamic pressure, $1/2\ \rho V^2$, lb/sq ft

V free-stream velocity, fps

ρ mass density of air, slugs/cu ft

α angle of attack of chord plane at root of model, deg

M Mach number, V/a

a speed of sound, fps

CORRECTIONS

The test data have been corrected for jet-boundary effects according to the methods outlined in reference 14. Blockage corrections were applied to the test data by the methods of reference 15. Reflection-plane corrections obtained from unpublished theoretical and experimental results were applied to the data in such a manner that the rolling-moment coefficients of the complete model were equal to 0.70 times the rolling-moment coefficients obtained for the semispan model.

MODEL AND APPARATUS

The semispan wing (fig. 1) had 45° sweepback of the quarter-chord line, an aspect ratio of 4.0, a taper ratio of 0.6, and an NACA 65A006 airfoil section parallel to the free air stream. The wing was mounted with the root chord adjacent to a turntable in the ceiling of the tunnel, the ceiling thereby serving as a reflection plane.

The wing was made of a steel spar covered with a bismuth and tin compound. The trailing edge behind the 50-percent-chord line was made from a laminated wood-plastic material.

The flap-type spoiler aileron used in this investigation was made of $\frac{3}{64}$-inch steel sheet to the dimensions shown in figure 1. The flap-type spoiler aileron was projected above the upper surface of the wing 5 percent of the local chord by bending the spoiler along the 0.52-chord line. The deflector was made in a similar manner but was deflected 5 percent of the local chord below the lower surface of the wing. It was deflected about the 0.66-chord line in such a manner that it would act as an air scoop. (See fig. 1.)

TESTS

Most of the tests were made at a dynamic pressure of 153 pounds per square foot, which corresponded to a Mach number of 0.33 and a Reynolds number of 3,250,000 based on the wing mean aerodynamic chord of 1.444 feet. Data at angles of attack greater than 30° were obtained at a dynamic pressure of 113 pounds per square foot, which corresponded to a Mach number of 0.28 and a Reynolds number of 2,700,000 also based on the wing mean aerodynamic chord.

DISCUSSION

The aerodynamic characteristics in pitch and the lateral-control data obtained by 0.05c projection of a flap-type spoiler aileron and of a flap-type spoiler aileron in combination with a slot and a deflector are presented in figure 2. The data at the higher Mach number (0.33) were limited to the angle-of-attack range shown because of structural limitations of the wing. The discussion, in general, will be confined to the positive angle-of-attack range. The negative angle-of-attack data are presented to show the characteristics of the spoilers in inverted flight.

A comparison of these results with the plain-wing data showed a slight decrease in the lift coefficient through a range of angle of attack from -8° to 60° with the spoiler projected. A further decrease of about $0.1C_L$ occurred when the deflector was projected and the slot was opened.

The drag coefficient at low angles of attack was increased when the spoiler was projected and further increased when the deflector was also projected and the slot opened. At angles of attack above about 16°, however, spoiler projection, particularly with the deflector and slot open, decreased the drag coefficient somewhat.

The model was longitudinally unstable in the angle-of-attack range between 8° and maximum lift coefficient. The plain-wing instability is in agreement with the high-speed data of references 16 and 17. Above maximum lift coefficient, however, the model became very stable. The spoiler arrangements investigated did not greatly affect the static longitudinal stability of the wing.

The rolling-moment effectiveness (fig. 2) of the spoiler alone increased slightly up to an angle of attack of about 12° and then decreased to zero at about 20° angle of attack. Projection of the deflector and opening of the slot increased the rolling effectiveness to about 3.5 times the rolling effectiveness obtained with the spoiler alone in the 0° to 12° angle-of-attack range. Above 12° angle of attack, the rolling moment of the spoiler-deflector-slot combination decreased rapidly to about 28° angle of attack but retained appreciable effectiveness up to an angle of attack of 60°. The increased rolling effectiveness of the spoiler-deflector-slot combination had been noted previously on the unswept wing of reference 6.

Chordwise pressure distributions obtained on a 35° sweptback wing (ref. 7) indicated that at the higher angles of attack the air flow was separated over the upper surface near the wing leading edge and was, therefore, not affected by spoiler projection. These results also indicated that a plug-type spoiler (spoiler with slot behind it) was more effective than a spoiler aileron, particularly at the higher angles of attack, because the air flow through the slot behind the plug-type spoiler caused a reduction in lift on the lower surface of the wing. The slot and the "scoop effect" of the deflector, in conjunction with the spoiler aileron of the present investigation, probably caused the increased rolling effectiveness in the same manner.

At 0° angle of attack, the yawing moments were more positive for the spoiler-deflector-slot combination than for the spoiler aileron alone. The yawing moments became unfavorable at about 20° angle of attack for the spoiler aileron and at about 11° angle of attack for the spoiler-slot-deflector configuration.

CONCLUSIONS

An investigation was made in the Langley 300 MPH 7- by 10-foot tunnel to determine the lateral control characteristics of a deflector and slot arrangement in conjunction with a flap-type spoiler aileron. The wing had a sweepback of 45° at the quarter-chord line, an aspect ratio of 4, a taper ratio of 0.6, and an NACA 65A006 airfoil section parallel to the free air stream. The results of the investigation led to the following conclusions:

1. The spoiler-deflector-slot combination was more effective than the spoiler aileron alone in producing rolling moment.

2. The spoiler-deflector-slot combination maintained appreciable rolling-moment effectiveness through a range of angle of attack from about -12° to 60°.

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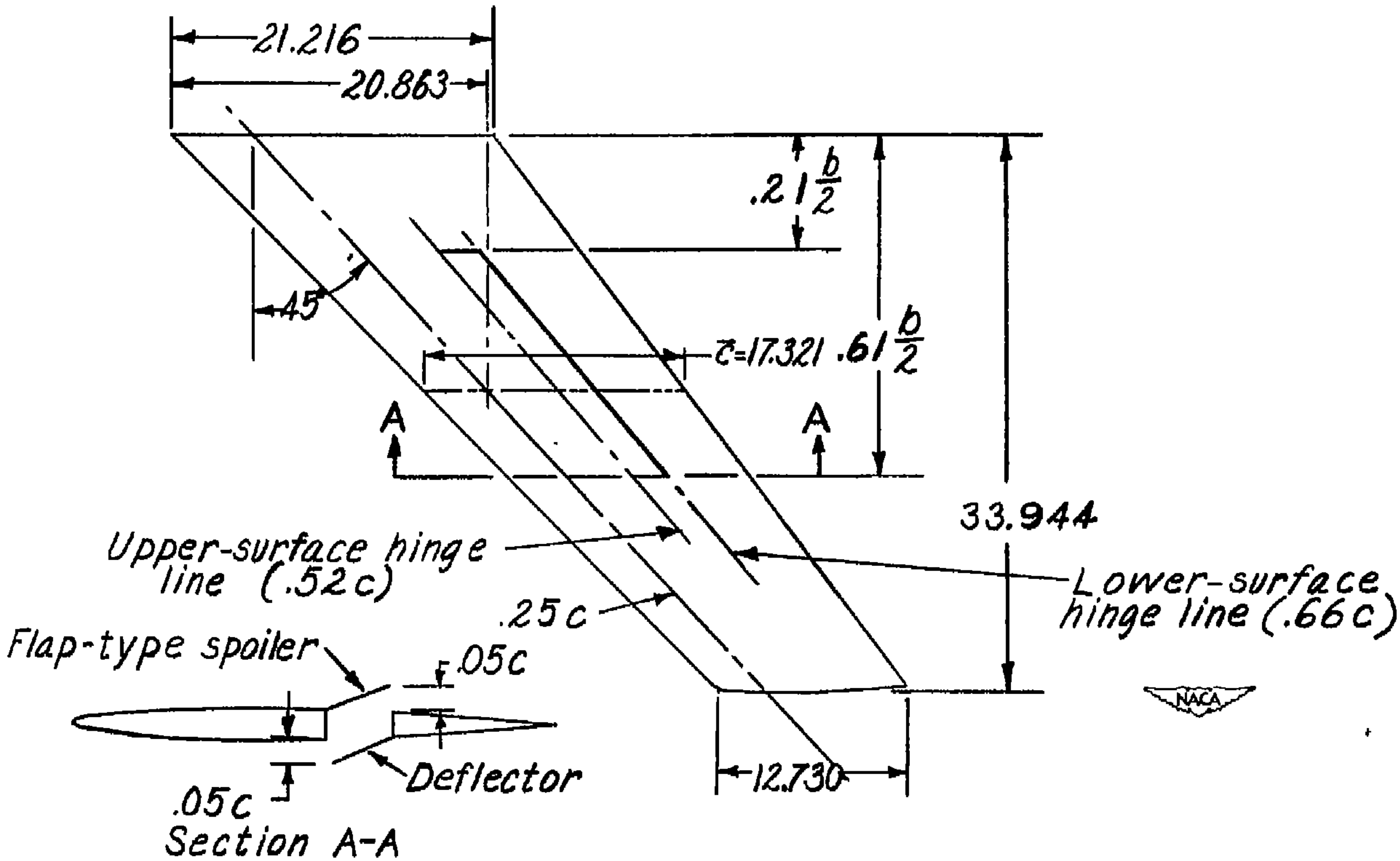

Figure 1.- Dimensions of the flap-type spoiler aileron, deflector, and slot on the wing swept back 45° with an aspect ratio of 4 and a taper ratio of 0.6.

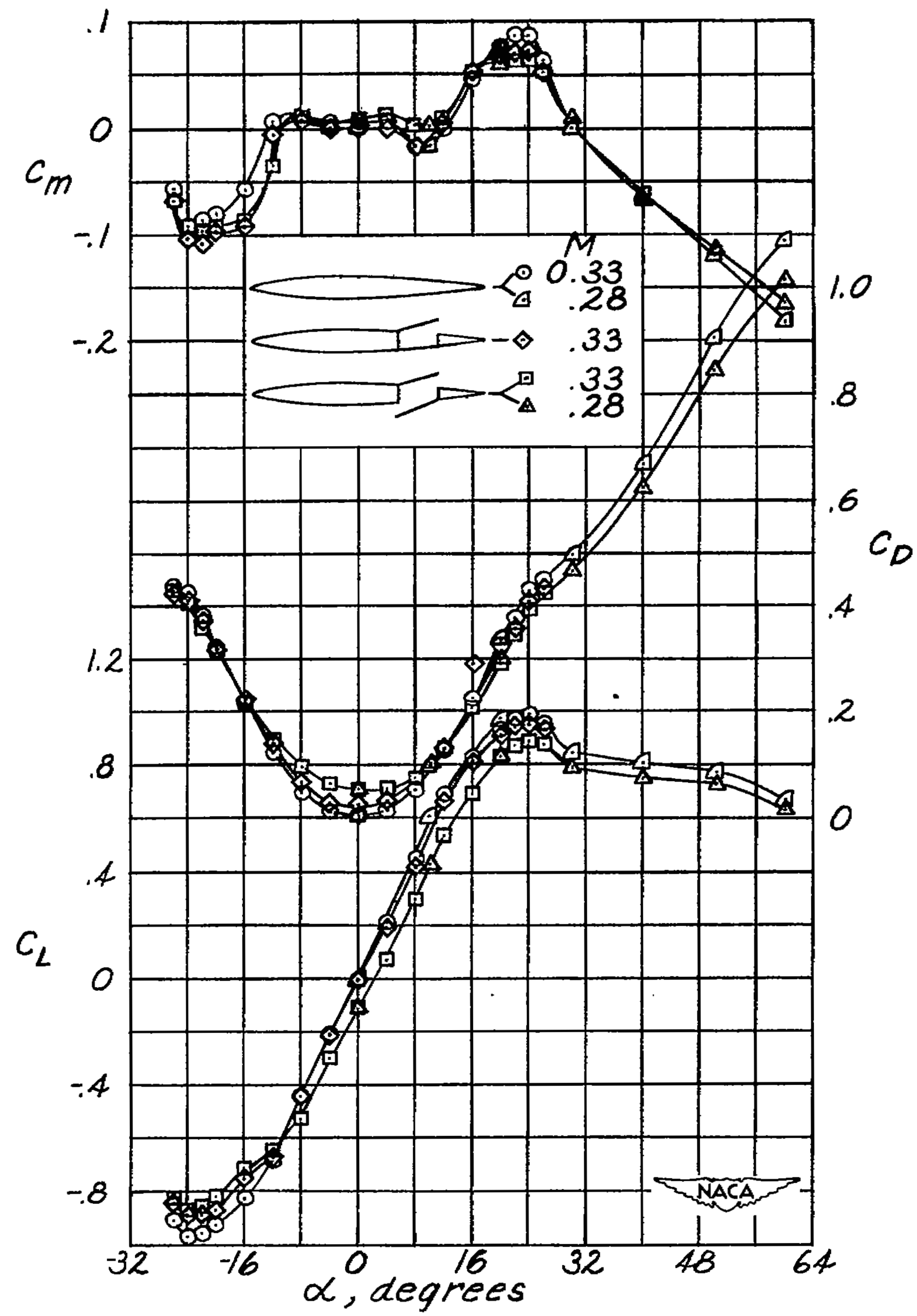

Figure 2.- The aerodynamic characteristics of the flap-type spoiler aileron with and without a deflector and slot on a wing swept back 45° with an aspect ratio of 4 and a taper ratio of 0.6.

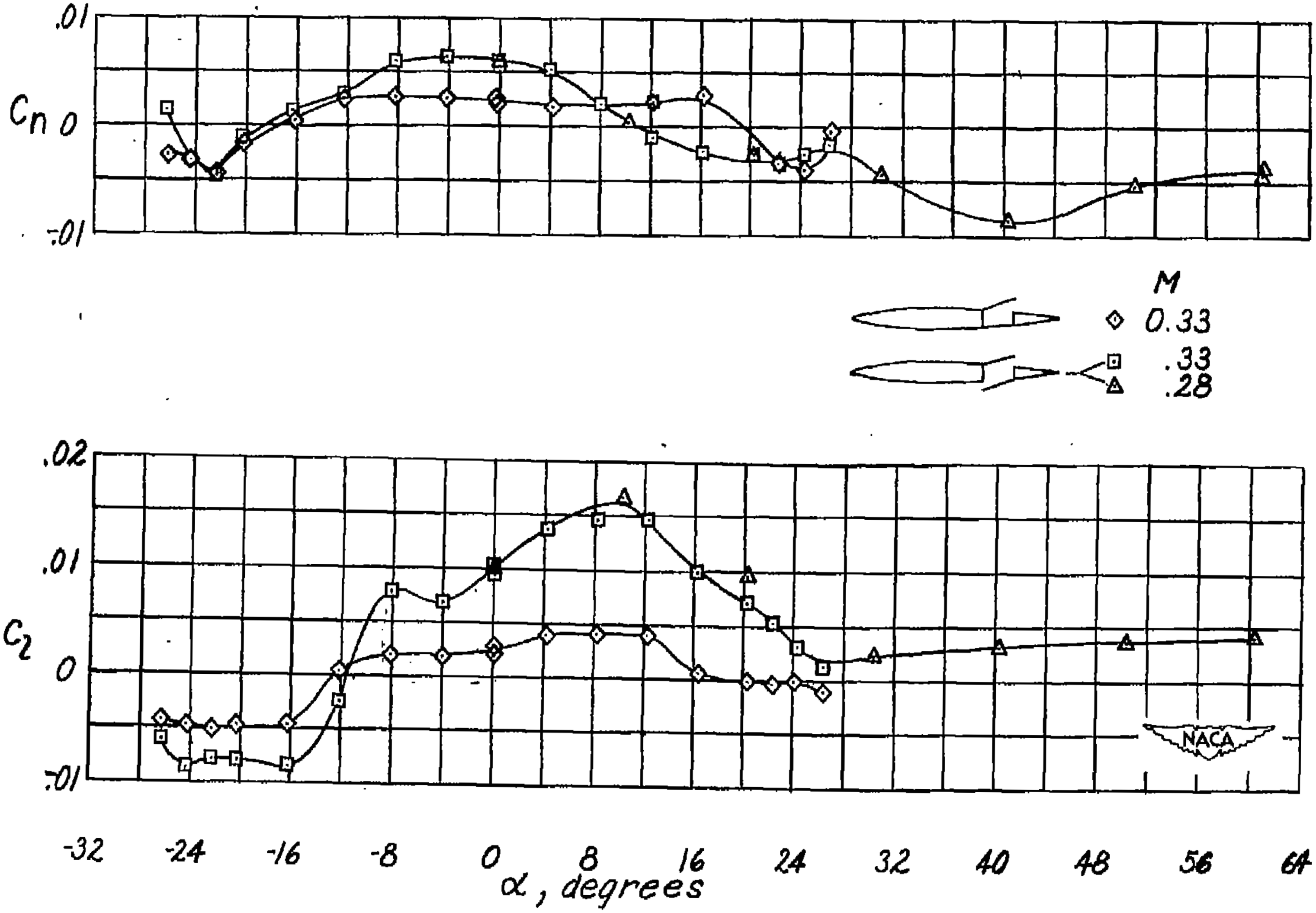

Figure 2.- Concluded.

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